A PERSONAL EXTRAPOLATION OF CDF TEST BEAM USE TO THE SSC

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Summary

The previous Snowmass report included a summary of testbeam usage by collider detectors by John Cooper[1] which is a valuable resource in estimating eventual SSC test beam needs. In this report I will give a personal view of the CDF experience and attempt to extrapolate to SSC needs at the point of turnon.

In order to set the scene, some physical and sociological description of CDF is required. CDF, shown in Figure 1, is basically a miniature version of the nominal SSC open detector, in which towers are large (.1 x .15),calorimetry is somewhat thin, and muon coverage is incomplete. The complement of about 200 physicists from more than 14 institutions now includes a large number of students. Tracking devices have been largely the province of the FNAL CDF group while calorimetry, muon systems, silicon detectors etc. have been produced by outside institutions and assembled at Fermilab. The calorimetry, which is scintillator based above about 30 degrees and gas below, has been the overwhelmingly dominant source of test beam usage. The efforts of the various scintillator calorimetry groups was forced into relative coherence by the beginning of module production and testing. The gas groups remained relatively independent in test beam use with coherence forced by assembling the overall detector. Each calorimeter includes extra modules for systematic studies with CDF in place.

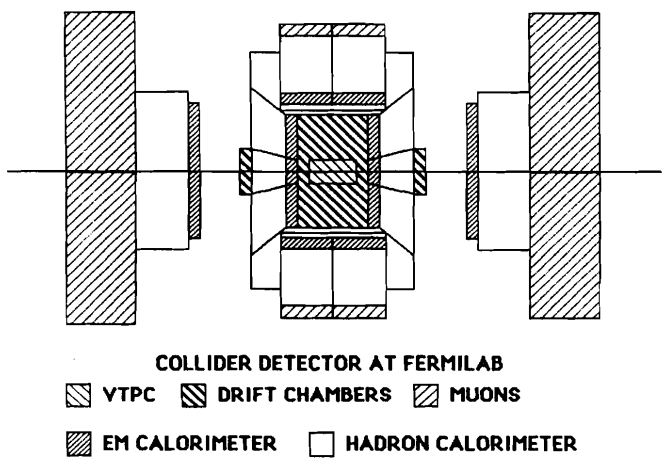

Figure 1. Layout of CDF. Vertical scale is expanded.

My personal involvement in test beam usage has been with the central EM calorimeter, from R&D through planning for future studies.

The CDF test beam usage, tabulated by Cooper, was limited by circumstance, and more running would have been quite useful. On the other hand, if more beam time had been available, we would have been hard pressed to make good use of it. In general, the effort and pain involved in making good use of test beam time is comparable to a fixed target experiment, eg. twelve full time equivalent working physicists were involved in the central calorimeter effort for the NW beam. Cosmic rays, sources, etc. were used wherever possible. It is sociologically unfortunate that the early smaller R&D test beam efforts typically had little student involvement.

A considerable amount has been accomplished in the course of CDF test beam usage. First, the rather reasonable design for CDF reflects a fair amount of test beam R&D. More might have made the design even better. Calibration, mapping, and some studies of systematics have been done for production modules. Greater test beam opportunity would have allowed better calibration in some cases, less dependence on cosmic rays with different systematics for mapping, and additional systematics studies which have been scheduled for future running. The forseeable future test beam running is booked solid with mostly studies that could in principle have been done in the past. One particular study, not yet done at all, is calorimetry response below 10 GeV, which other groups have found to be even less linear than ours are above 10 GeV. Various boundary regions also need to be explored. These and other studies will compete with any recalibration needs and whatever new questions arise from data taking.

For SSC test beams, first round R&D is irrelevant. To extrapolate the CDF experience, I assume that the first round of detectors will consist of a major open detector of a scale at least twice that of CDF, with many more subgroups, a closed 4π detector, and two sets of specialized detectors with each set on the scale of CDF. In addition, at the time of SSC turnon, I assume an active program of R&D for the next generation of detectors. The scale of CDF is reflected in the active use of 1.5 test beams immediately preceding turnon. Thus the first round detectors would extrapolate to at least 6 test beams, assuming the closed detector needs nothing. If different calorimetry designs require less calibration time, surely they will demand more opportunity to study systematics since they will have better nominal performance. The 4 beams from the HEB described in the Design Report[2] will likely be a squeeze on the first round groups and may force second generation R&D to find a home elsewhere, which is culturally very unfortunate. The squeeze would be relieved if the HEB beams come on early and run steadily, as the CDF test beam running at Fermilab has been subject to various construction shutdowns etc. On the other hand, commissioning studies of SSC injection may be a fair interruption.

Systematic calorimetry study needs will reflect the huge dynamic range at SSC. All the calorimeters of CDF reflect some level of nonlinearity and future ones should not be assumed to be perfect. I assume that providing lower energy beams would be relatively trivial. On the other hand, the high luminosity and long program at SSC imply observation of single particles of several TeV. CDF groups have studied electrons and pions up to 200 GeV which naively extrapolates to 4 Tev (assume luminosity cancels scale breaking). The exciting observation of a 2.5 TeV electron should not be an extrapolation of calorimeter performance by a factor of five. Demand for beam time for this particular study would not be all that great, so that all first round groups could share a single high energy test beam facility.

The most likely victim of a test beam squeeze at the SSC would be R&D for future generations. If a major new detector is to be completed say seven years after SSC turnon, its design probably needs to be fairly fixed within two years after turnon. Such a project is inevitable and it will need to demonstrate new technologies to justify the effort. Demonstration, as well as R&D, implies test beams.

In conclusion, the test beam demand will reflect the scale of effort involved in SSC detectors rather than the number of them. The inevitable squeeze will be eased somewhat if the HEB beams come on early and become steady. Provision should be made for later expansion. Test beam facilities, as well as detector electronics, should reflect the available dynamic range; in particular, a single high energy beam derived from the SSC could be shared with great benefit by several groups.

Test beam efforts offer a unique educational opportunity for graduate students to understand a measurement completely in detail, and should become a part of the cultural life of SSC.

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References

1. John Cooper, Proc. Snowmass 84, p. 462.

2. CDG, Conceptual Design of the SSC, March 1986.